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Insect Pest Introduction into Florida: Surveillance and Detection Efforts by Government Agencies

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Introduction

Movement of plants and animals began decades ago when people travelled from one continent to another in search of trade and migrated to escape social conditions in their homeland. As international travel by sea and air increased, so did the frequency with which species were transported around the world. A variety of insects, weeds, disease causing organisms such as fungi and viruses, as well as other potential pests has been purposefully and inadvertently introduced into North America (CAST, 1987). Many of these transplants have adapted to their new environment and the North American ecosystem has been modified by the non-native species that have successfully established and, in some cases, became invasive as they out competed native species for resources.

Many non-native plant species such as corn, wheat, and rice have become economically important agricultural food crops in the United States (Simberloff, 2000). An estimated 25% of the world's pathogens and 10% of its insect species pose significant threats to its agriculture (Huber et.al. 2002) but, this is rapidly changing. Insect species such as the Mediterrean fruit fly (*Ceratitis capitata*), and the Oriental fruit fly (*Bactrocera dorsalis*) are known pests in other countries and, if introduced into the United States, could adapt in those parts of the country with similar ecological conditions to their native range. Should either of these fruit flies become established in North America they could become damaging pests to a wide range of hosts, and would require extensive control and eradication efforts (Newell, 1928).

The United States is regarded as a "melting pot" of ethnic groups and a "stew" of crops and insect pests (Huber et.al. 2002). Over the past three decades, agricultural, social, and industrial activities have altered the natural balance of the country's ecosystems. The rate of introduction of potential pest insects has accelerated significantly as a result of: (1) increasing

commercial and recreational travel by air and sea, (2) growing numbers and expanding ports of entry to facilitate larger vessels such as cargo ships, (3) expanding export and import markets, and (4) improved access to foreign commodities. In addition, because of the large volume of commercial and recreational travel within and across its borders, the continental United States has been, and continues to be, especially prone to insect pest introduction. Consequently, throughout the past two decades, a greater number of invasive non-indigenous insects and pathogens such as Asian cycad scale, *Aulcaspis yasumatsui*, citrus greening (Huanglongbing), emerald ash borer, *Agrilus planipennis*, and laurel wilt disease caused by the fungus, *Raffaelea lauricola* and vectored by the beetle *Xyleborus glabratus* have become established in the United States contributing to economic losses in excess of $137 billion per year (Pimentel et.al. 1999, Ciesla, 2002).

International trade has been recognized as the major conduit by which non-indigenous insect pests enter the United States (National Plant Board, 1999). It is estimated that more than 4,500 arthropod species have been introduced into the United States 95% of which were accidental (Pimentel, et. al. 1999). Many species enter through non-agricultural and agricultural cargo, on produce or plant propagative materials in travelers' baggage, and as hitchhikers on airplanes, trucks and ships. In Florida, for example, an estimated 11, 500 native species, and more than 949 species were introduced accidentally (Frank & Mc Coy, 1995a), successfully established and became invasive in the state.

Florida's proximity to Central America, South America, and the Caribbean has become the major transit point for trade and commerce between the United States and these countries (Caton et.al. 2006). With, (1) increasing international and domestic travel within and across its borders, (2) growing numbers of entry ports, (3) large numbers of export and import markets and

(4) improved access to foreign markets, Florida has become vulnerable to insect pest invasion. An estimated 55% of all goods shipped between the United States and Central America, 44% of U.S. cargo bound for, or arriving from the Caribbean and, 30% of the trade with South America passes through Florida (Caton et.al. 2006). Experts say at least one new insect enters the state each month, potentially threatening agricultural crops and native species (Crabbe, 2006, Frank & Thomas, 2004).

Today, Florida's most important crops such as corn, peppers, and snow beans owe their existence to constant vigilance by the Florida Department of Agriculture (FDACS), United States Department of Agriculture (USDA) and Customs & Border Protection Agricultural Specialists (CBP); all three agencies work together to keep many dangerous pests out of the state. Diligent Inspectors working alongside the Customs Officers, meet all arriving vessels that arrive by land, sea, or air. The Officers inspect cargo and passengers' baggage, the holds of vessels, cabins, crew's quarters and store rooms of vessels themselves to keep out potential insects hitch-hiking on commodities or on the vessels. The interception of insects, diseased plants, and disease causing organisms is a daily occurrence. Numerous attempts are made to smuggle plants into the state and each year the ever increasing array and speed of commercial and private means of transportation add to the difficulty of detecting and excluding foreign pests. The objective of this paper is to summarize the different modes of insect introduction into Florida over an eleven year period (2005-2015), and to discuss the surveillance and detection efforts undertaken by government agencies: Florida Department of Agriculture and Consumer Services (FDACS), Custom and Border Patrol (CBP) and United States Department of Agriculture (USDA).

Methodology

In this study, records of non-native organisms intercepted by CBP, FDACS and USDA personnel during inspections of baggage, cargo consisting of plant propagating materials, fruits and vegetables and mail associated with transport vessels such as planes, ships and container trucks originating outside of Florida were collected for the period of 2005 to 2015. A total of 60,298 records, each representing an organism intercepted at five points of entry: Miami International Airport, Miami Port Inspection Station, Port Everglades, Fort Lauderdale Airport and West Palm Beach Port Inspection Station were accessed from CBP PIN database. In addition, a total of 230 samples from the trapping efforts of the Marinas and Canal Survey program which operated under the umbrella of the Cooperative Agriculture Pest Survey Program directed by the Florida Department of Agriculture and Consumer Services and Plant Pest Surveys conducted by Inspectors were included in the analysis.

Patterns in insect interceptions and possible pathways were assessed by evaluating the number and location of country of origin and points of entry, the type of infested commodities for all insect interceptions. Non-native, non-indigenous species or introduced species are those organisms that have outside their native ranges to areas in which they don't naturally occur. Baggage refers to materials carried on board or in the luggage of passengers who arrive in Florida on ships, airplanes, or on personal vehicles. Cargo refers to commercial shipments of materials arriving at airports, marine ports or transported in trucks crossing the Florida borders. The origins of insect pests were determined for major regions of introduction.

Pathways and Patterns for Insect Pests Introduction

A total of 60, 298 interceptions, representing six groups of organisms were used in this analysis. Five points of entry in Florida, mainly south Florida where non-native plant and plant pest interceptions were recorded. Insects were consistently intercepted at much greater rates than any other group of organisms, with an annual average of 5,481 interceptions (Figure 1). Insects were the leading group, comprising 88.9% of all interceptions, mites with 5.9%, mollusks with 3.2 % and diseases and weeds with an average of 0.9% respectively. Other studies (McCullough et. al. 2006, Dobbs & Brodel, 2004) have recorded similar results where insect is the dominant taxa intercepted on imported commodities such as consumables and propagating materials intended for planting.

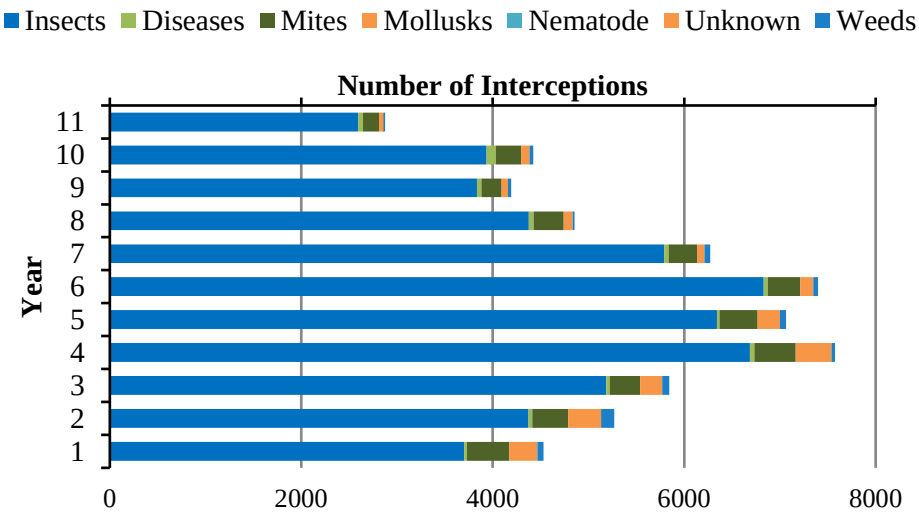

Figure 1. Number of interceptions of non-native plants and plants pests by taxa and year from 2005 to 2015.

Florida, known for its warm and sunny climate has relatively more introduced species: 11,509 native and 993 introduced species ((Frank & McCoy, 1995a) than any other state. Every imported shipment of plants and other commodities offers opportunity to plant-feeding insects to

immigrate as hitch-hikers on vessels and stow-aways in or on, imported commodities. These insects can go undetected and even escape inspection until their populations increase under conditions such as those in Florida. Insect interceptions were continuously high on consumables with an annual average of 3,572 interceptions. Propagative materials intended for planting recorded an average of 1,114 interceptions, annually while non-entry materials had an average of 2,087 annual interceptions (Figure 2). Annual interceptions on material intended for consumption spiked but remained stable during year 2009 to 2011 and then rapidly declined thereafter. Overall, 73.0% of insects were intercepted on imported commodities intended for consumption, 23% associated with plant materials intended for propagation such as live plants, rooted cuttings and 4% of insects on materials classified as "non-entry," which indicates that the materials associated with the pest is not allowed entry into Florida.

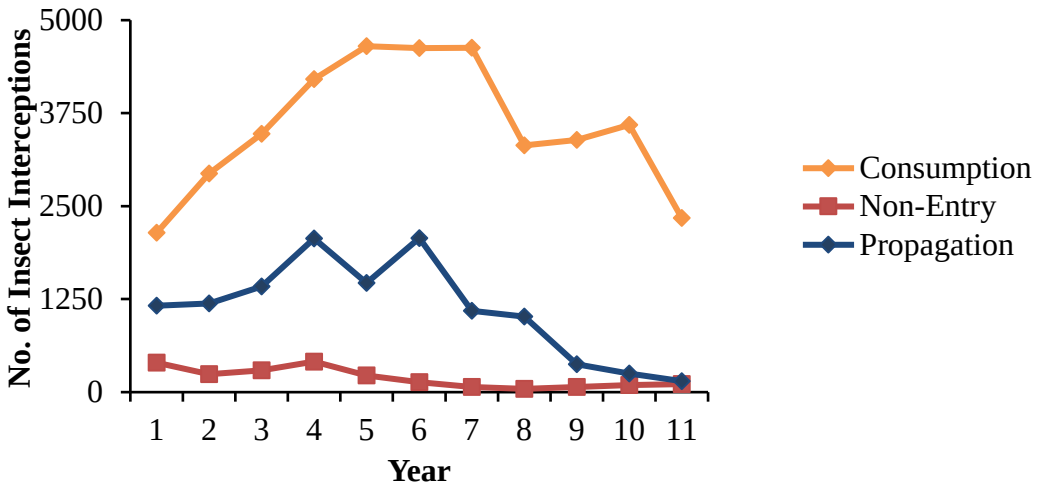

Figure 2. Number of interceptions on three modes of entry from 2005-2015

Others studies (McCullough et. al. 2006) have found 87% of interception to be on imported commodities intended consumption. It is not surprising that consumables were the most common commodities on which insects were intercepted. Insects and other arthropods are able to

conceal themselves under bark or in wood, buds, or roots by virtue of their small size. Further, some have cryptic coloration or structures that limit their visibility and detection on the commodities or vessels on which they “travel”.

During the 11-year period examined, 72% insect interceptions were made from cargo which included insects recovered from general cargo brought in on ships and those from air cargo, 24% interceptions were from traveler’s baggage and 4% as non-entry which comes in through mail, ship and airline holds, and other miscellaneous means (Figure 3).

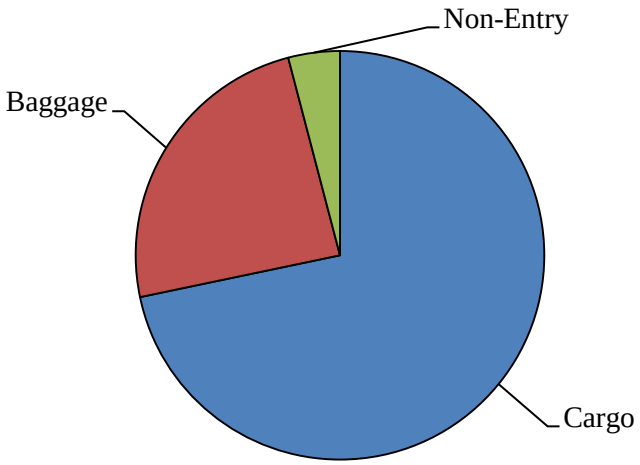

Figure 3. Number of non-native insect intercepted from baggage, cargo and non-entry materials

In this study, plant and plant pests were intercepted from three major regions, totaling 32 countries. Over the 11 year period, there was an annual average of 3,033 insect interceptions from Central America, 1,325 interceptions from the Caribbean and 518 interceptions from North America (Figure 4). Majority of the insect pests were from Central America which accounted for 62% of all insect interceptions from 7 countries, and the Caribbean which was 27% from 23 countries. North America, including Mexico accounted for 10% of insect interceptions.

Interceptions of insects originating in Central America were consistently high over the 11-year period, while interceptions from Caribbean and North America remain relatively low. All three regions showed a continuing decrease in the last six years. Dobbs & Brodel, (2004) found similar patterns of insect interceptions coming from Central America in which contamination rates were greatest, 23% on cargo flights coming from Central America, and much lower, near 5% on flights from all other regions.

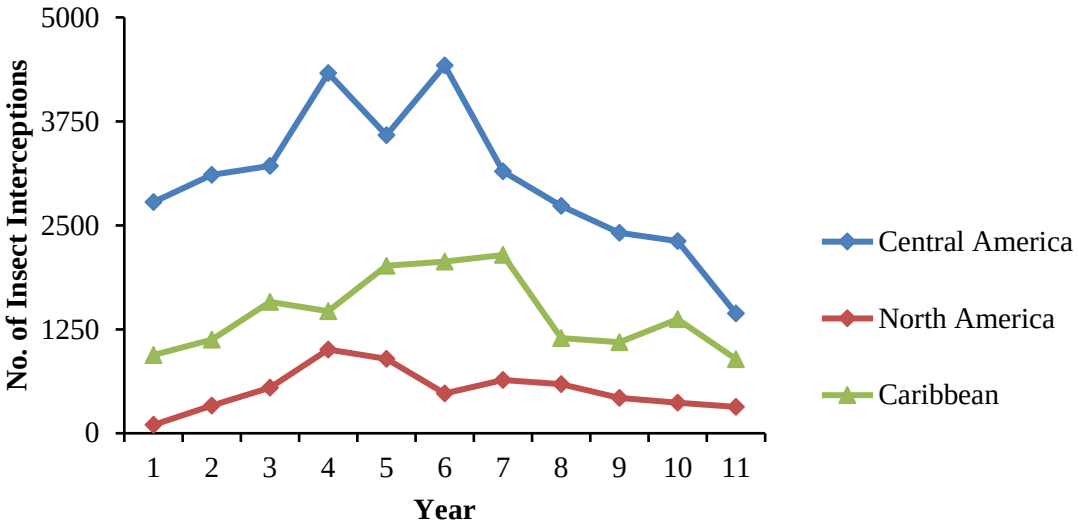

Figure 4. Number of insect interceptions by year from 2005-2015 from countries in three regions.

The spread of plant pests has been facilitated as intercontinental air commerce has flourished. The frequency of air travel has meant that cargo containing eggs, seeds, spores, or any other living stage of an organism can be transported from almost any point on the globe to the United States within 24-36 hours — well within the survival time of a many of species, compared with the weeks or months at sea that can be fatal for many species. Thousands of shipments are discovered every year to contain insect stowaways, but only 2% of all imported

shipments are inspected at ports and airports increasing the chances that non-indigenous insects might escape. Should they do so and go undetected, they could establish in their new environment and cause major damage to our agricultural industry and native ecosystem. Plant pest surveys and trapping have revealed more than two hundred thirty new insect pest introductions from 2007-2015. During the last 7-years examined, 24% of the new insect pests collected were from the order Coleoptera, 23% Hemiptera, 16% Lepidoptera, 10% each for Diptera and Acari and 1% Homoptera (Figure 6).

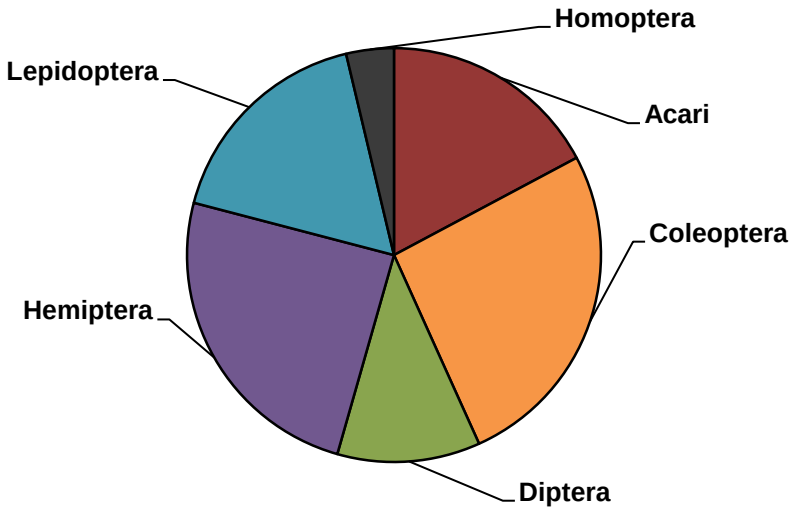

Figure 6. Major orders of introduced insect pests detected from 2007 to 2015

In Florida, shipments of plants entering the United States use Miami International Airport as their major transit point. These, along with shipments of other kinds of cargo that arrive by air, sea, and land, have been, and continue to be, the main method of introduction of Florida's most important insect pests.

Impacts

Non-indigenous insects pose one of the greatest threats to Earth's ecosystems. Global trade and the movement of people and goods have caused massive shifts in insect populations, introducing insect species to areas where they have no natural predators. This can have serious economic and environmental consequences and once established are hard to stop. Without predators, parasites, and pathogens to keep them in check, non-native insect populations increase unimpeded.

Numerous accidentally introduced insect species and pathogens have become major agricultural pest. For example, the Asian citrus psyllid, vector for the citrus greening disease arrive around 1998 and has become the most devastating disease affecting our citrus industry, causing major economic lost in revenue more than $7.8 billion, 7,513 job loss and loss of productive lands of more than 160, 000 acres since 2007 (Southeast Farm Press, 2016). Laurel wilt disease is threatening our avocado industry. Commercial avocados grow on 7,500 acres, almost exclusively in Miami-Dade County, and account for more than 60 percent of Florida's tropical fruit production. Non-native fruitflies such as the guava, mediterrean and oriental fruit flies are a common threat to South Florida. In 2015, South Florida experienced a major outbreak of the oriental fruit flies (*Bactrocera dorsalis*) in Homestead causing the state millions of dollars in eradication efforts.

Introduced insects can vector or, be reservoirs of diseases of humans, domestic animals, cultivated plants, and wild animals and plants. The spread of yellow fever, dengue and of recent the Zika virus as the vector mosquito *Aedes aegypti* dispersed throughout the tropics, and of malaria to Brazil with the introduction of its vector *Anopheles gambiae*, are notable examples of

human diseases vectored by introduced insects. The mosquito, *Ochlerotatus japonicus*, transmits West Nile virus to both birds and humans in the northeastern United States. Cat fleas (*Ctenocephalides felis*) and dog fleas (*C. canis*), introduced to Australia with their hosts, are intermediate hosts for the dog tapeworm (*Dipylidium caninum*).

Some non-native insect species can change the shape and structure and functioning of entire ecosystems. A recent list of the world's 100 worst introduced species included 15 insects, but at most one would qualify as having a huge ecosystem-wide impact: the little fire ant (*Wasmannia auropunctata*), and the red imported fire ant (*Solenopsis invicta*) affect other ants greatly, and sometimes other insects, but to date none has had the dramatic impact of certain plants and mammals. In South Florida, over 60 species of ornamental figs were not invasive because their obligatory pollinating wasps were absent. Since the 1970s, three such wasps (*Parapristina spp.)* have arrived, and three formerly innocuous fig species have begun spreading in natural areas.

Regulations

The original Plant Quarantine Act in 1912 gave the Animal and Plant Health Inspection Service (APHIS) authority to regulate the importation and interstate movement of nursery stock and other plant materials that may carry pests and diseases that are harmful to agriculture. This act ensures all plants and most plant products entering the United States have been subject to inspection, and action has been taken to prevent entry of arthropod pests. It has since been superseded by the consolidated APHIS statue, The Plant Protected Act of 2000 which is important to the agency's ability to prevent or limit the spread of harmful invasive species within

or to a state or region of the United States. FDACS working alongside USDA/APHIS to protect the state from harmful organisms and to issue quarantine measure to stop their spread.

Surveillance and Detection Strategies

The protection of Florida's agricultural industries against the introduction of insect pests is at the core of the mission of both FDACS and the USDA. The department is vigilant for the introduction of non-native species and works with partner agencies, CBP and USDA, to continuously survey for their introduction, particularly at areas e.g. airports and fruit orchards, at highest risk for these introductions. The Division of Plant Industry is the front line in the state's defense and is involved in numerous surveillance and detection programs including: (1) Fruit Fly Trapping, (2) Plant Pest Surveys, (3) Public Outreach Programs (4) Export and Import Monitoring, (5) Biological Control and (6) Detector Dogs Program.

1. Fruit Fly Trapping

Fruit flies are one of the most potentially destructive pests in the world. They have a wide host range of fruits, vegetables and nuts, and most of Florida's crops, including citrus. FDACS and the USDA are working together to prevent the spread of non-native fruit flies that entered Florida on infested fruits and vegetables. Two approaches are in use in detecting and regulating fruit flies if any are present: (a) Male Annihilation Technique involves the use of a high density of bait stations consisting of a male lure combined with an insecticide (usually technical malathion, and more recently fipronil), to reduce the male population of fruit flies to such a low level that mating does not occur. With the technique, more than 55, 000 fruit fly traps are placed in strategically high-risk areas of Florida by the cooperative efforts of FDACS and USDA.

(b) Sterile Insect Technique involves the rearing and releasing of sterile males in different areas throughout the state. Mediterrean fruit fly pupae are imported from Guatemala and reared in Palmetto, Florida. Biweekly releases are made in excess of one millions flies. With these two techniques, state has succeeded in eradicating introduced fruitfly populations from Florida.

2. Plant Pest Surveys

The Marinas and Canal Survey program which operated under the umbrella of the Cooperative Agriculture Pest Survey Program directed by the Florida Department of Agriculture and Consumer Services and Plant Pest Surveys by Inspectors carry out surveys for high-risk pests. Many types of surveys are carried out including moths and exotic pest surveys, cotton boll weevil, tomato farm surveys and those around marinas and parks. Trapping types used are Lindgren funnel traps, Delta traps and Bucket traps.

3. Public Outreach Programs

Florida Department of Agriculture and Consumer Services, in partnership with the U.S. Department of Agriculture's Animal and Plant Health Inspection Service, and the U.S. Department of Homeland Security's Customs and Border Protection have developed a collaborative campaign The “Don't Pack a Pest” campaign to increase awareness of the importance of declaring agricultural products brought into the United States by travelers. Since its launching in 2011, signage has been placed throughout Florida's major ports of entry and in six Caribbean locations where “Don't Pack a Pest” partnerships have been implemented – these include Jamaica, Dominican Republic, Puerto Rico, the U.S. Virgin Islands, Cayman Islands,

and now Turks and Caicos Islands. There are now over 680 program signs displayed in 52 ports of entry in the U.S. and the Caribbean.

4. Export and Import Monitoring

USDA is in charged with protecting America's agriculture. A part of that charge is to ensure that non-native insect pests do not enter and destroy United States produce and commodities. USDA and State inspectors regulate products that are brought into the country by certifying that they are 'pest-free' prior to import and export. Permits are issued when commodities are inspected and found free from injurious pests and diseases.

5. Biological Control

The introduction of parasites and predators into Florida dates back to 1899 when the vedalia, *Rodolia cardinalis* was introduced to control the cotton-cushion scale, *Icerya purchase* Maskell, Many more non-native insects have been introduced intentionally, especially to serve as biological controls and have proven to be successful. The Pink Hibiscus Mealybug (*Maconellicoccus hirsutus)* program in Florida became a success when *Anagyrus kamali* parasitoids were release to suppress the populations. The *Cryptolaemus* larvae, a predator were also used in this program. Many other biological control programs that are presently ongoing and these include: The *Leptinotarsa defecta* to control tropical soda (*Solanum viarum)* and *Lilioceris cheni*, the air potato leaf beetle to control the air potato (*Dioscorea bulbifera*) vine, an invasive weed.

6. Detector Dog Program

The USDA program has trained dogs for a number of functions, including: airport passenger clearance for the USDA, Department of Homeland Security, Customs and Border Protection, and foreign countries such as Taiwan, Japan, Mexico, Cayman Islands, Canada, South Africa and Puerto Rico; the Brown Tree Snake Program on Guam; state agencies, including Florida's Agriculture Law Enforcement Division, State of Florida Department of Plant Industry, and California's Department of Food and Agriculture; and various domestic invasive initiatives, such as the Asian longhorn beetle, giant African land snail, nutria and brown marmorated stink bug. FDACS dogs have been involved in detection of the giant African snail, packages at FedEx facilities throughout Florida.

Conclusion

With the growth of international trade with Asia, Central America and South America, there will be a continuous problem of invasive non-native species overrunning the United States, and in particular Florida, causing incalculable economic and ecological costs. Federal and State responses have not stemmed this tide; indeed, it has risen. Only a massive reworking of government policies and procedures at all levels and a greatly increased commitment to coordinating efforts can redress this situation. To address these trade issues, the federal government must be committed to limiting the import of exotic pests and must present a coordinated federal strategy to support restrictions.

Surveillance and detection efforts are ongoing but there are practical limitations to finding many insect pests through inspections, only 2% of all produce and plants are inspected, the amount of plant material coming into Florida is increasing. Once in new habitat, these

introduced insect species can transformed the plant diversity, costing the state and country in eradication and control efforts to millions of dollars. It is therefore imperative that FDACS, CBP and the USDA continue to monitor for the introduction for non-native species, many of which are potential pests of US agriculture and native biodiversity. It is also important that Florida growers and those interested in the protection of the environment are cognizant of this situation and take steps to deal with inevitable losses and increased expenditures required to address new pests.

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